ANSYS

IDAJ CAE Solution Conference

Your True Partner for CAE&CFD

ICSC 2015

发动机液压悬置系统的流固耦合分析

ANSYS CHINA
技术部 杨帆

IDAJ ANSYS

ANSYS产品咨询:
Email: ansys@idaj.cn
Tel: 010-65881497; 021-50588290

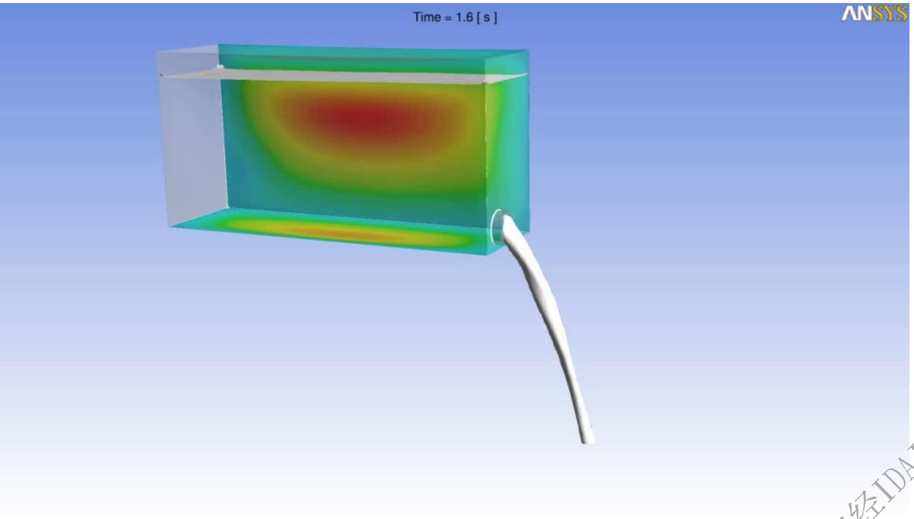
内容简介

- 流固耦合技术简介
- 发动机液压悬挂系统双向耦合仿真设置
- 发动机液压悬挂系统双向耦合仿真结果
- 总结

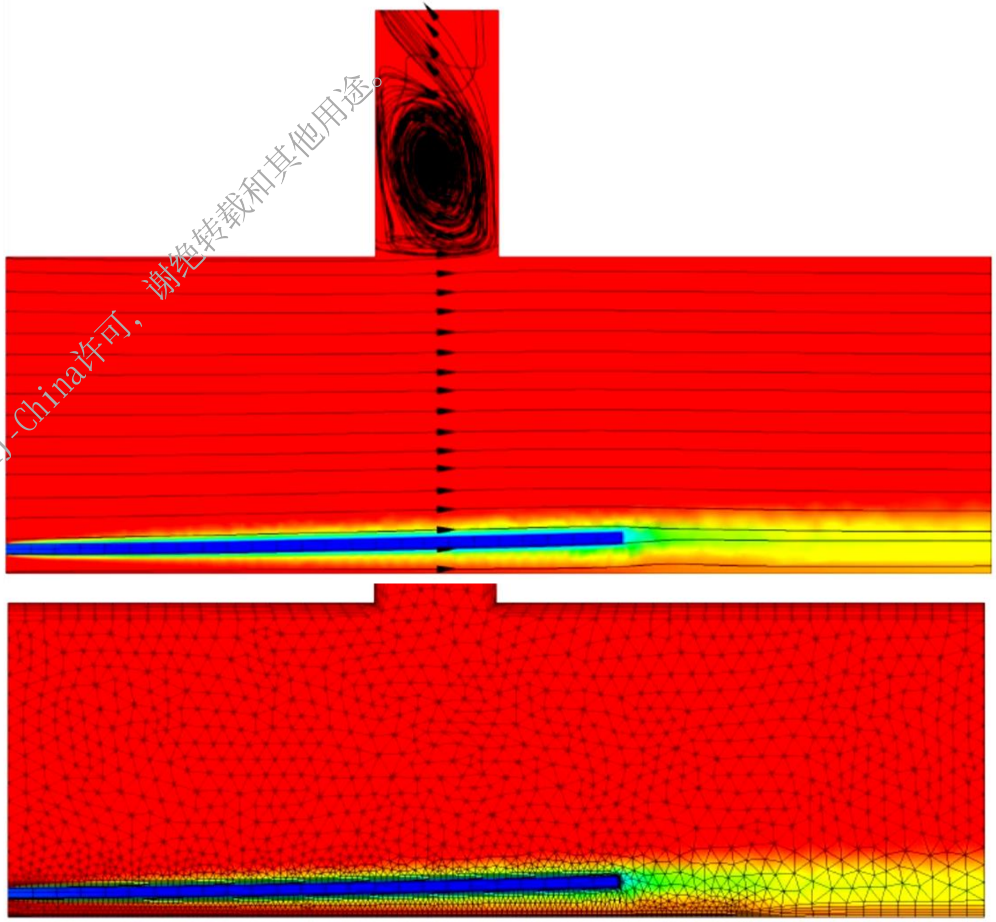
流固耦合分类

	单向耦合	双向耦合
压力耦合	流体计算 ↓ 压力载荷 结构计算	流体计算 边界位移 ↑ ↓ 压力载荷 结构计算
热耦合	流体计算 ↓ 压力+热载荷 结构计算	流体计算 边界位移 ↑ ↓ 压力+热载荷 结构计算

双向流固耦合示例

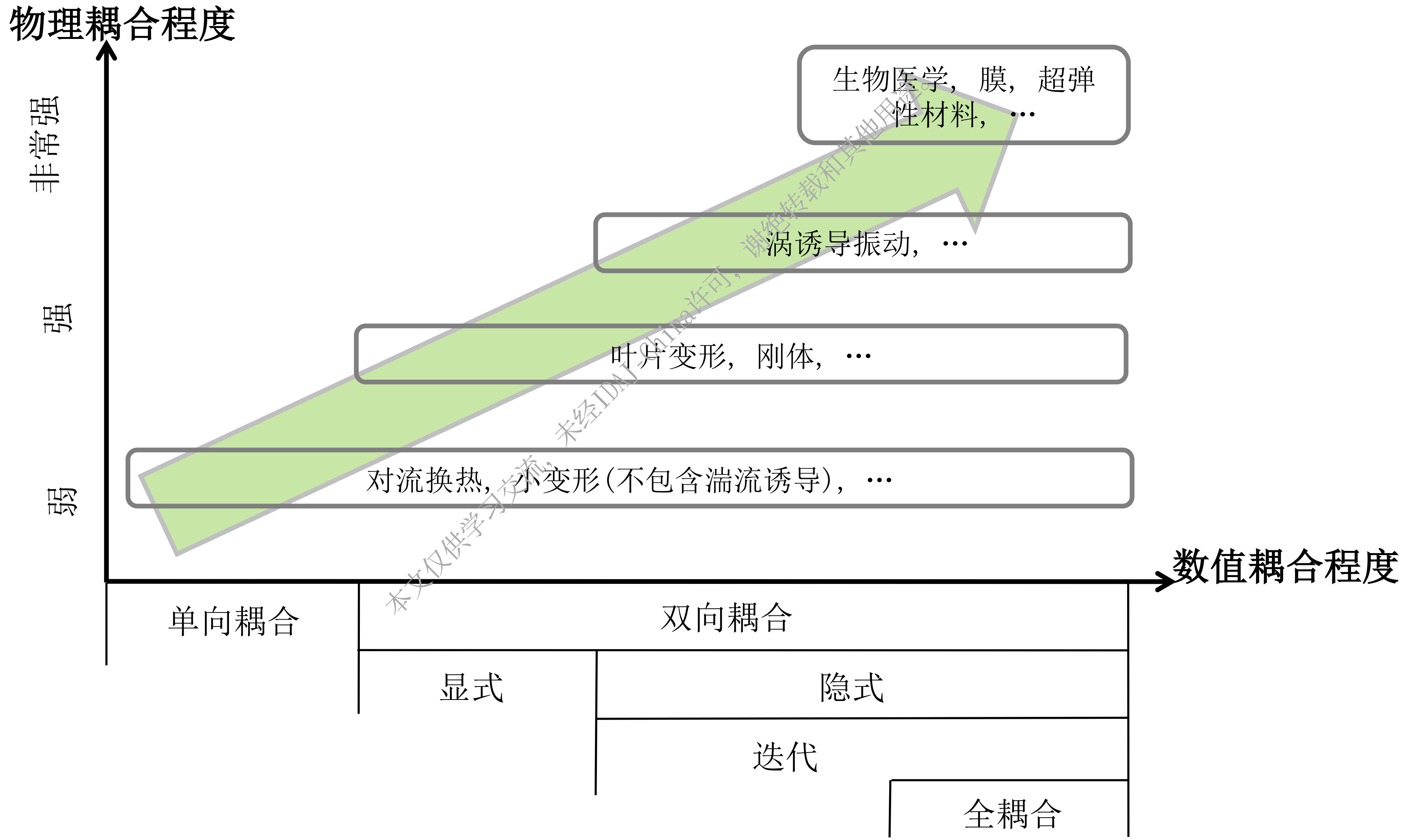


压力耦合



热耦合

不同工况耦合程度分析

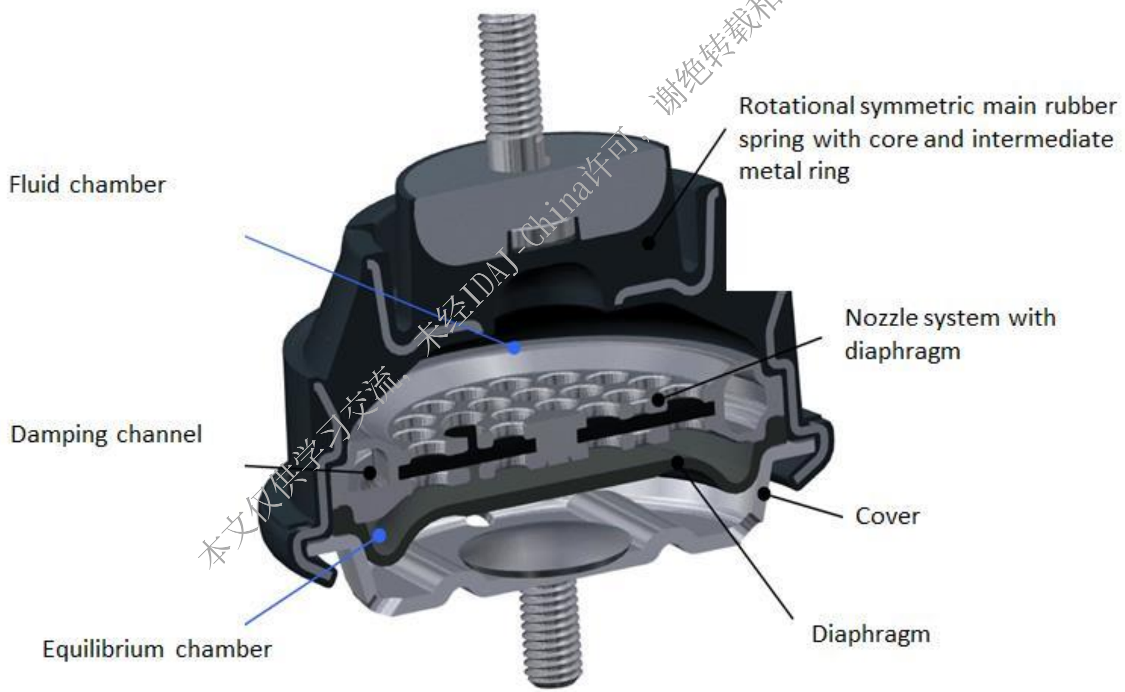

物理耦合程度
非常强
强
弱
生物医学，膜，超弹性材料，…
涡诱导振动，…
叶片变形，刚体，…
对流换热，小变形（不包含湍流诱导），…
数值耦合程度
单向耦合
双向耦合
显式
隐式
迭代
全耦合

内容简介

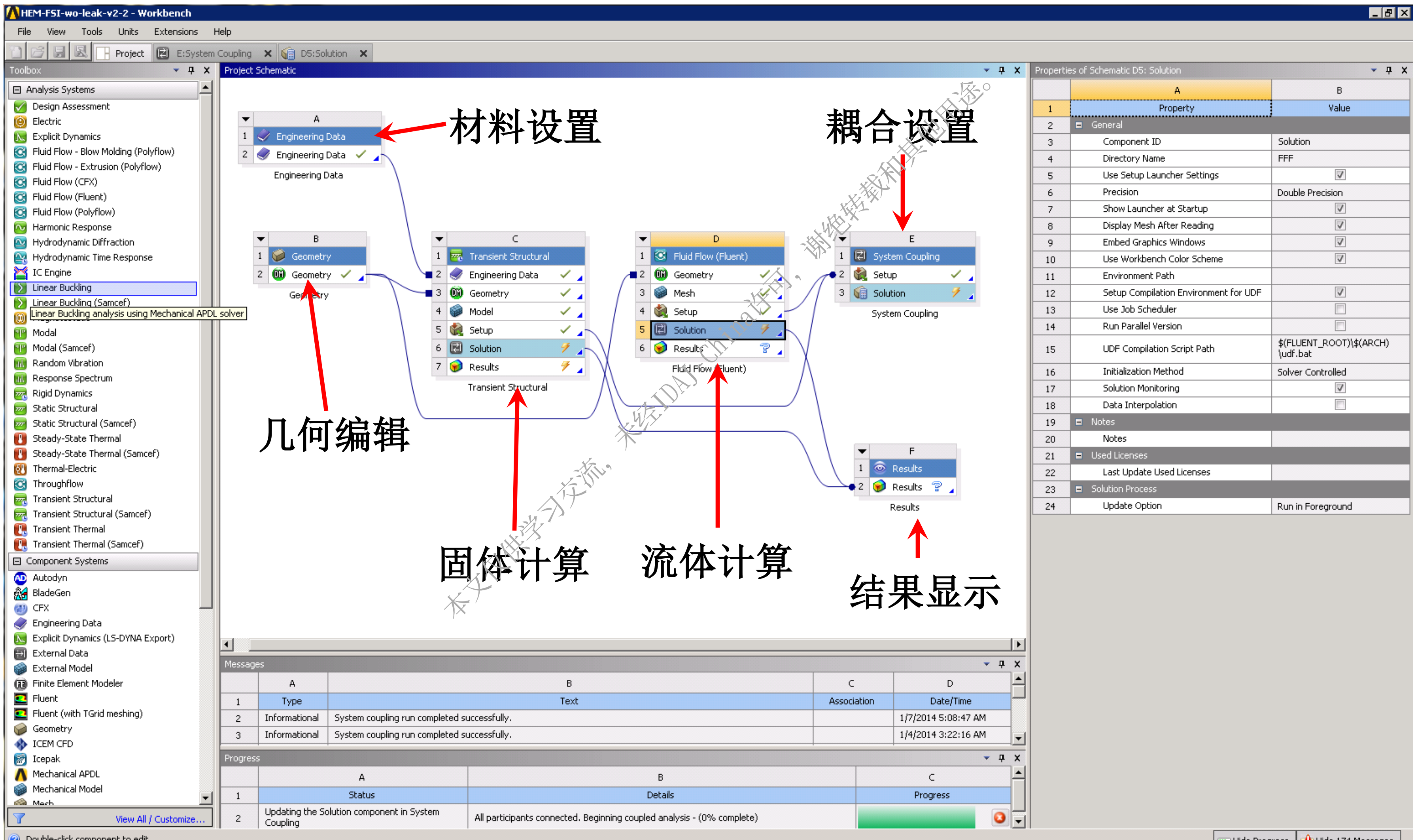
- 流固耦合技术简介
- 发动机液压悬挂系统双向耦合仿真设置
- 发动机液压悬挂系统双向耦合仿真结果
- 总结

分析目的

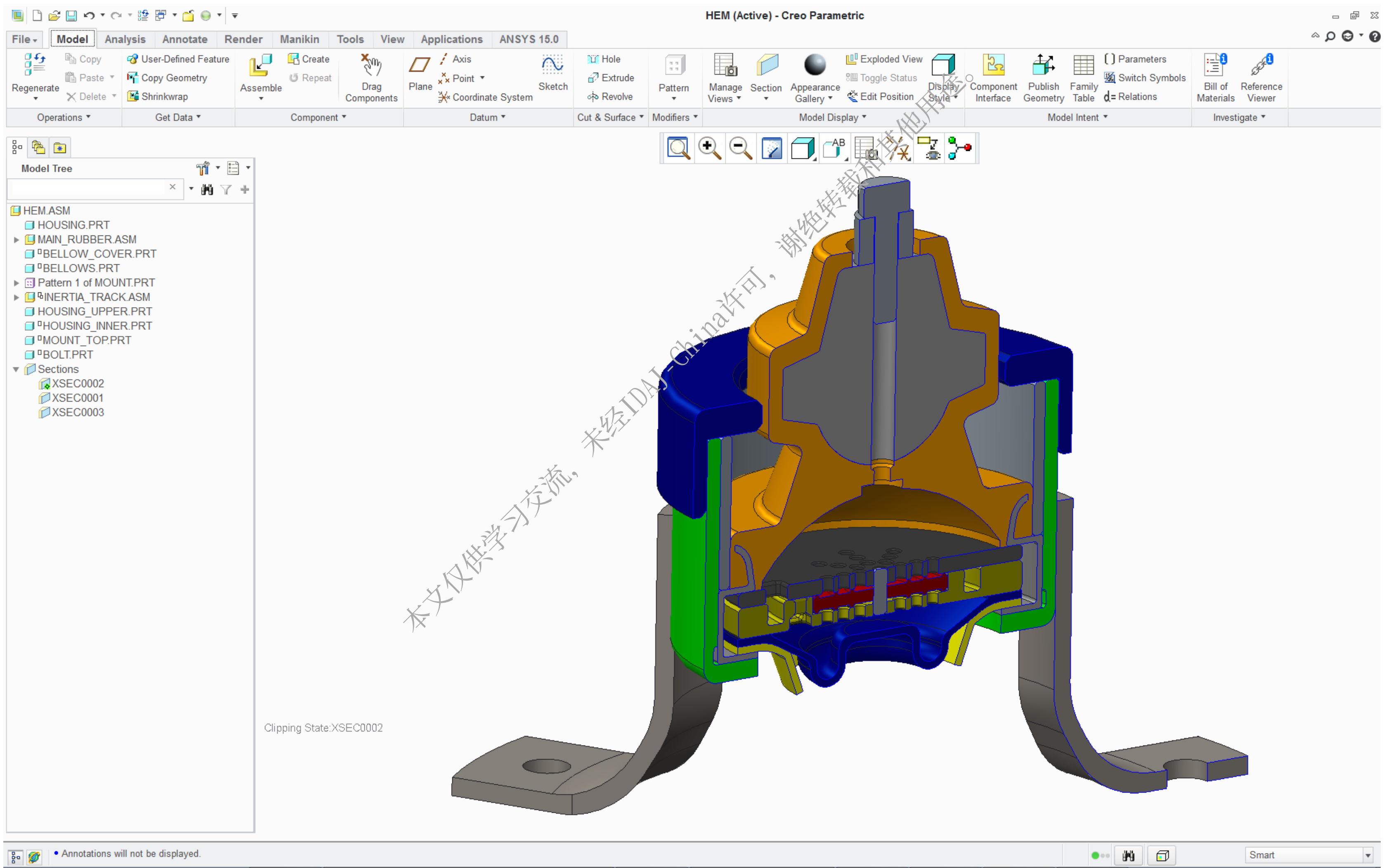
- 分析的目的是考察发动机液压悬挂系统的输入激励(扫频离散辐值)对动态刚度和相位角的影响及相应的噪声预测.



流固耦合分析流程


HEM-FSI-wo-leak-v2-2 - Workbench
材料设置
耦合设置
几何编辑
固体计算
流体计算
结果显示
Engineering Data
Geometry
Transient Structural
Fluid Flow (Fluent)
System Coupling
Results
本文仅供学习交流，未经IDAJ China许可，谢绝转载和其他用途。

PRO/E模型


HEM (Active) - Creo Parametric
File
Model
Analysis
Annotate
Render
Manikin
Tools
View
Applications
ANSYS 15.0
Regenerate
Copy
Paste
Delete
User-Defined Feature
Copy Geometry
Shrinkwrap
Assemble
Create
Repeat
Drag Components
Plane
Axis
Point
Coordinate System
Sketch
Hole
Extrude
Revolve
Pattern
Manage Views
Section
Appearance Gallery
Exploded View
Toggle Status
Edit Position
Display Style
Component Interface
Publish Geometry
Family Table
Parameters
Switch Symbols
Relations
Bill of Materials
Reference Viewer
Operations
Get Data
Component
Datum
Cut & Surface
Modifiers
Model Display
Model Intent
Investigate
Model Tree
HEM.ASM
HOUSING.PRT
MAIN_RUBBER.ASM
BELLOW_COVER.PRT
BELLOWS.PRT
Pattern 1 of MOUNT.PRT
INERTIA_TRACK.ASM
HOUSING_UPPER.PRT
HOUSING_INNER.PRT
MOUNT_TOP.PRT
BOLT.PRT
Sections
XSEC0002
XSEC0001
XSEC0003
Clipping State:XSEC0002
Annotations will not be displayed.
Smart

材料属性设置

固体材料:

- 橡胶1
  - Mooney-Revlin C_{10} = 0.00025 Mpa, C_{01} = 0.5 MPa^{-1}
- 橡胶2
  - Mooney-Revlin C_{10} = 0.0002 Mpa, C_{01} = 0.4 MPa^{-1}
- 非橡胶材料为刚体

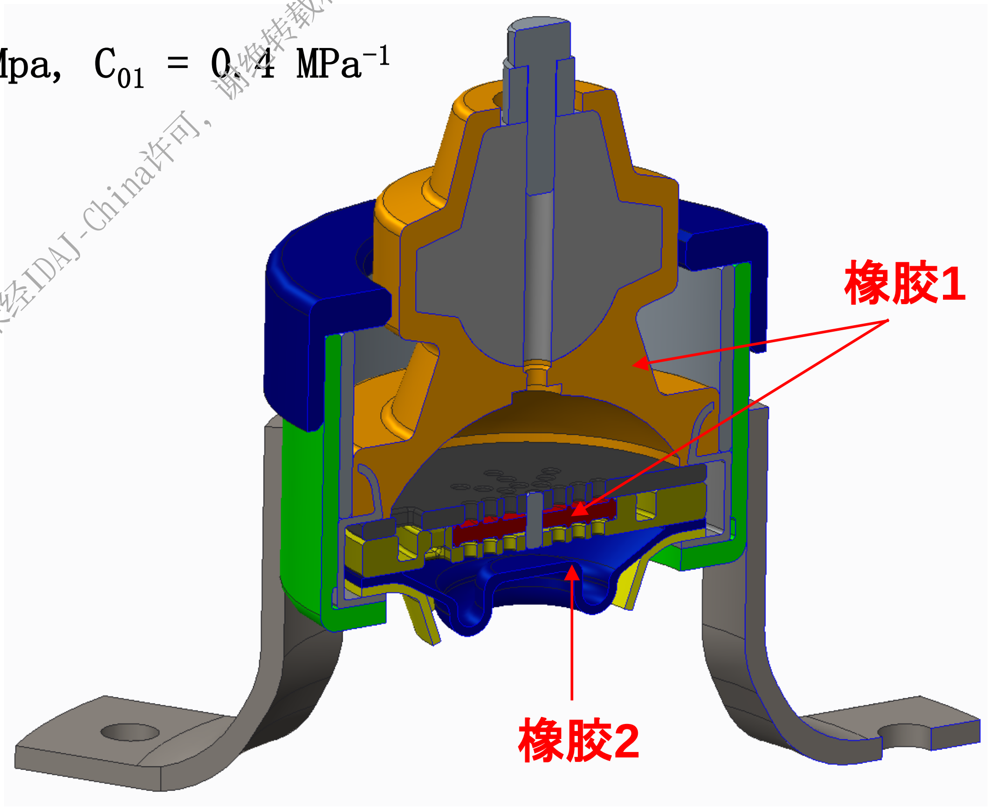
乙二醇（假设为可压缩液体）

E = 2 Gpa

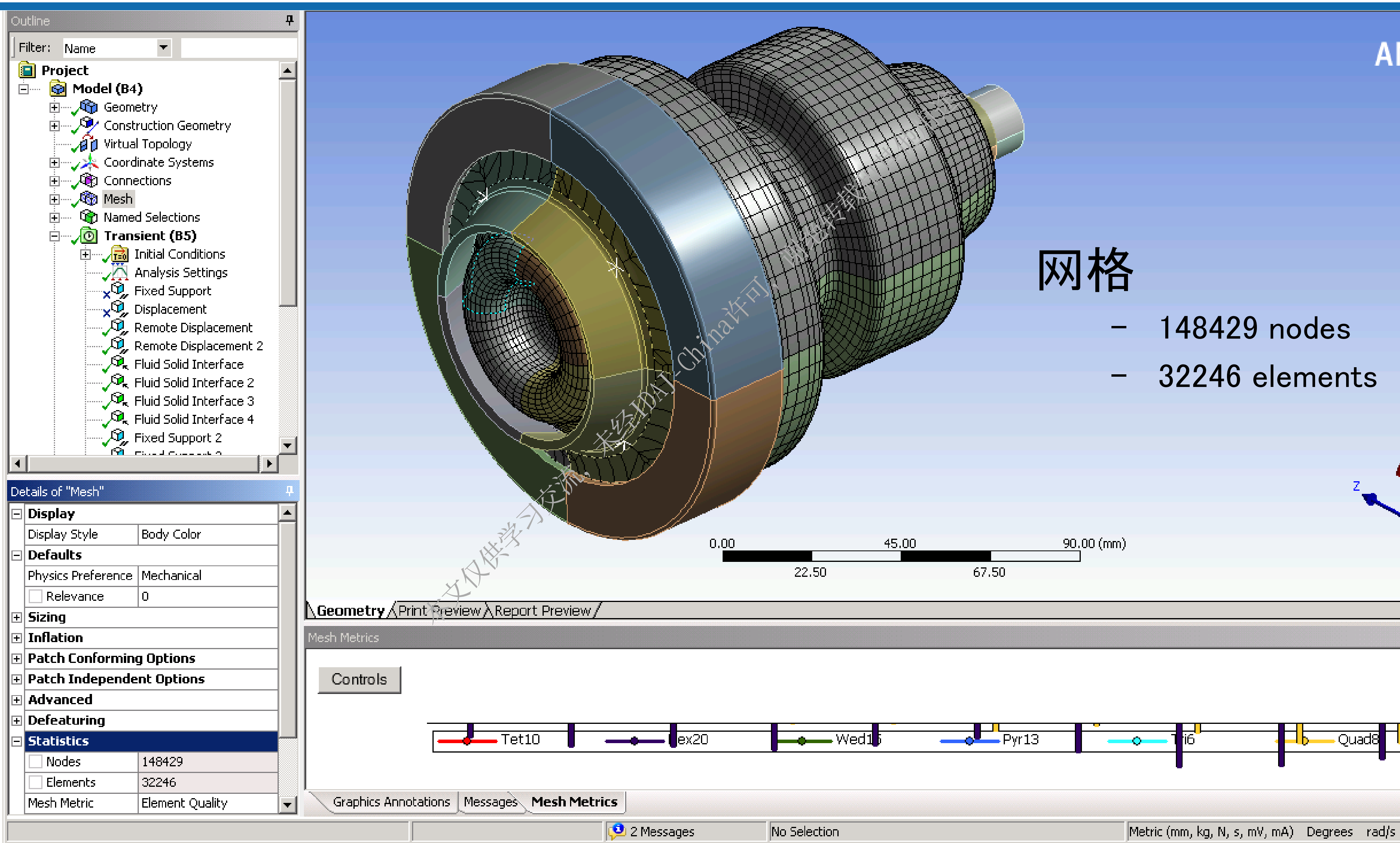
v = 1.2e-5 kg/ms

Rho ref = 1314.425 kgm^-3

P ref = 101325 Pa



固体网格划分



网格

- 148429 nodes
- 32246 elements

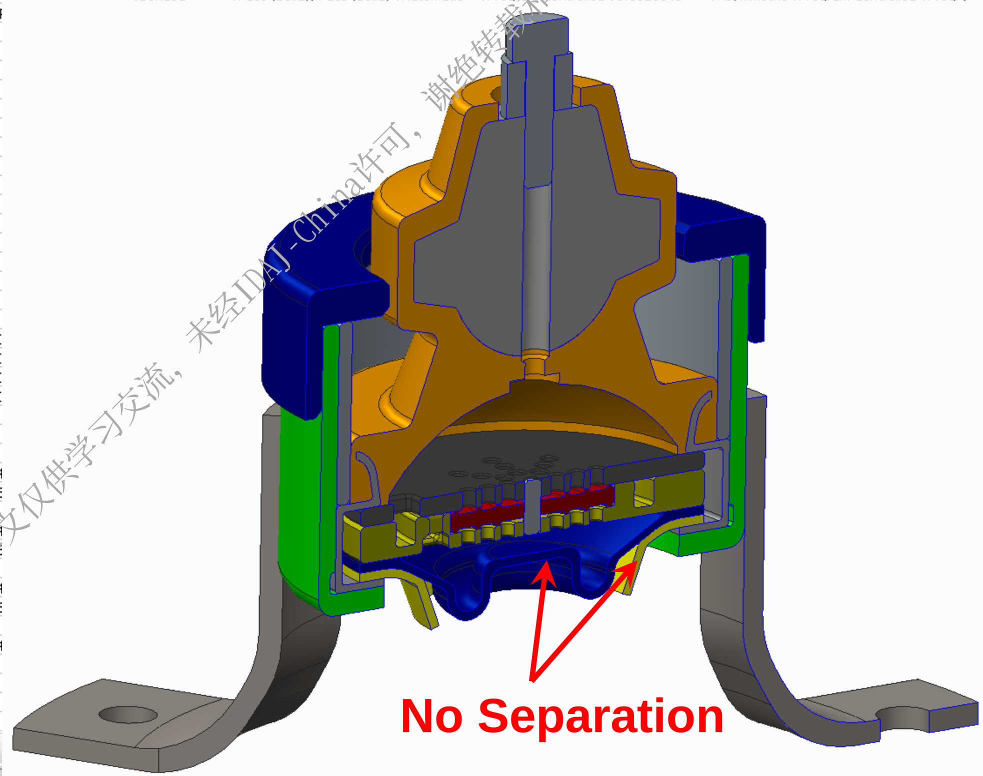
固体约束设置

自动生成接触：底部橡胶与橡胶盖设置为No Separation，其他设置成Bonded

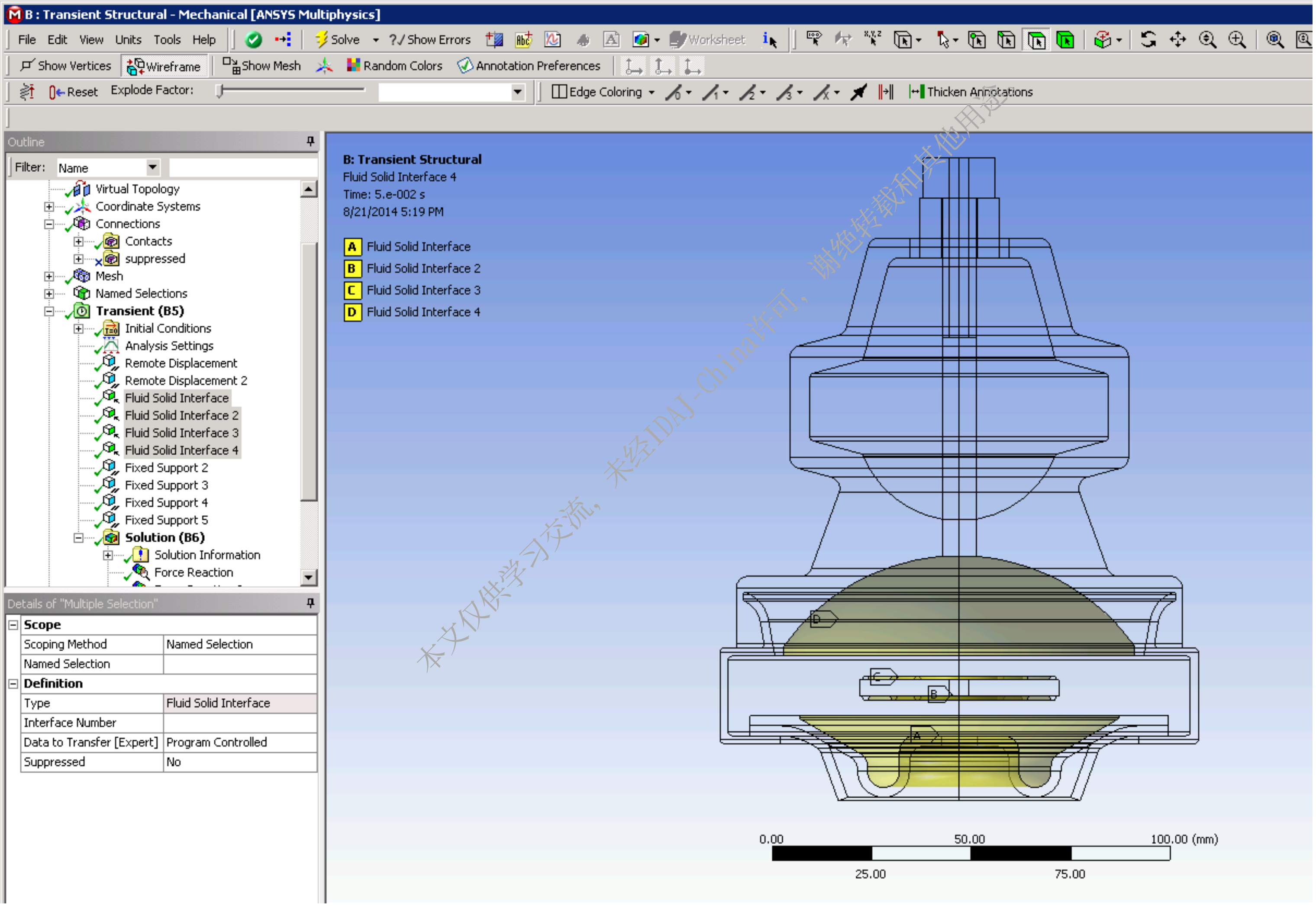
Name	Type	Scope	Scope Mode	Trim Contact	Trim Tolerance	Behavior	Normal Stiffness	Updat
No Separation - BELLOWS[1547] To BELLOW COVER[1706]	No Separation	Face (Solid), Face (Solid)	Manual	Program Controlled	N/A	Asymmetric	Program Controlled	Progra
No Separation - BELLOWS[1547] To BELLOW COVER[1706]	No Separation	Face (Solid), Face (Solid)	Manual	Program Controlled	N/A	Asymmetric	Program Controlled	Progra
No Separation - BELLOWS[1547] To BELLOW COVER[1706]	No Separation	Face (Solid), Face (Solid)	Manual	Program Controlled	N/A	Asymmetric	Program Controlled	Progra
No Separation - BELLOWS[1547] To BELLOW COVER[1706]	No Separation	Face (Solid), Face (Solid)	Manual	Program Controlled	N/A	Asymmetric	Program Controlled	Progra
Bonded - BELLOWS[1547] To BELLOW COVER[1706]	Bonded	Face (Solid), Face (Solid)	Manual	Program Controlled	N/A	Asymmetric	Program Controlled	Progra
Bonded - DECOUPLER CAGE LOWER[3946,40] To DECOUPLER[3946,45]	Bonded	Face (Solid), Face (Solid)	Automatic	Program Controlled	1.0123143	Asymmetric	Program Controlled	Progra
Bonded - DECOUPLER CAGE LOWER[3946,40] To DECOUPLER CAGE UPPEI								
Bonded - DECOUPLER CAGE LOWER[3946,40] To PIN[3946,247]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To BELLOWS[1547]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To DECOUPLER[3946,45]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To BELLOWS[1547]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To DECOUPLER[3946,45]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To BELLOWS[1547]								
Bonded - DECOUPLER CAGE LOWER[3946,40] To DECOUPLER[3946,45]								
Bonded - DECOUPLER[3946,45] To DECOUPLER CAGE UPPER[3946,46]								
Bonded - DECOUPLER[3946,45] To PIN[3946,247]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To PIN[3946,247]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER[3604,44]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To DECOUPLER[3946,45]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER[3604,44]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To DECOUPLER[3946,45]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER[3604,44]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To DECOUPLER[3946,45]								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER REINFORC								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER REINFORC								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER REINFORC								
Bonded - DECOUPLER CAGE UPPER[3946,46] To MAIN RUBBER REINFORC								
Bonded - PIN[3946,247] To DECOUPLER[3946,45]								
Bonded - PIN[3946,247] To DECOUPLER[3946,45]								
Bonded - PIN[3946,247] To DECOUPLER[3946,45]								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT[3604								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT 2[36								
Bonded - BELLOWS[1547] To BELLOW COVER[1706]								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT[3604								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT 2[36								
Bonded - BELLOWS[1547] To BELLOW COVER[1706]								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT[3604								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT 2[36								
Bonded - BELLOWS[1547] To BELLOW COVER[1706]								
Bonded - MAIN RUBBER[3604,44] To MAIN RUBBER REINFORCEMENT[3604								
Bonded - MOUNT TOP[7158] To BOLT[7161]								
Bonded - MOUNT TOP[7158] To MAIN RUBBER REINFORCEMENT[3604,45]								
Bonded - BOLT[7161] To MAIN RUBBER REINFORCEMENT[3604,45]								
Bonded - MOUNT TOP[7158] To BOLT[7161]								

Graphics Worksheet

2 Messages

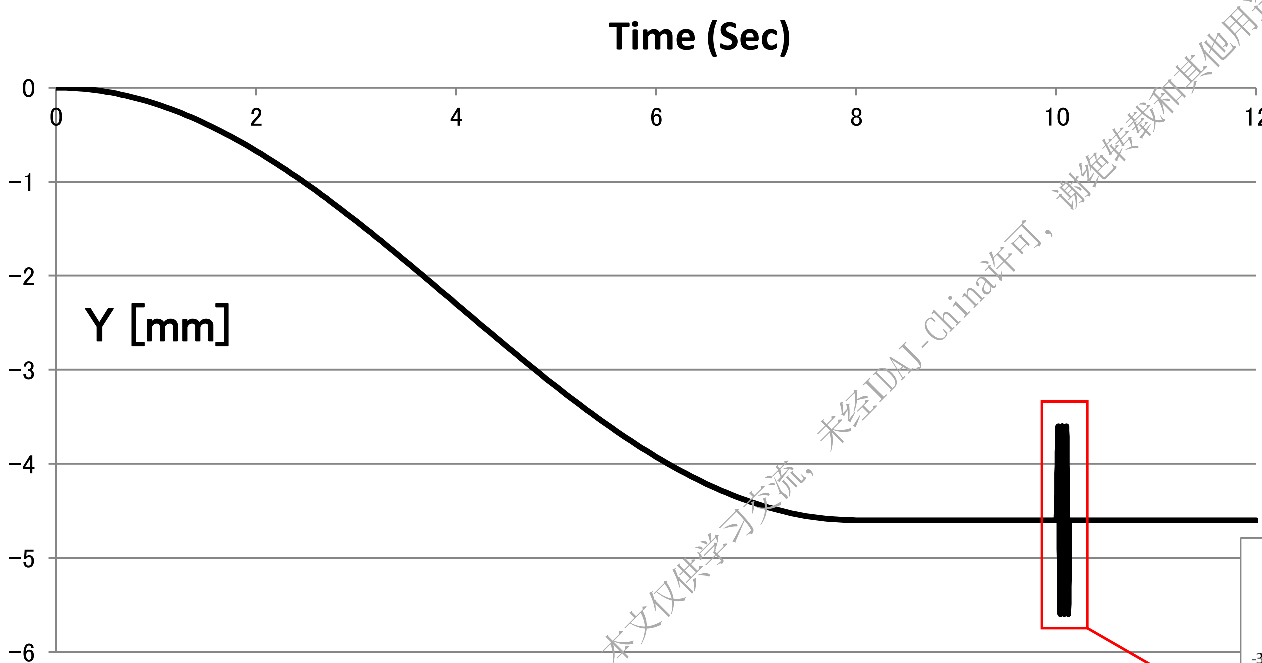


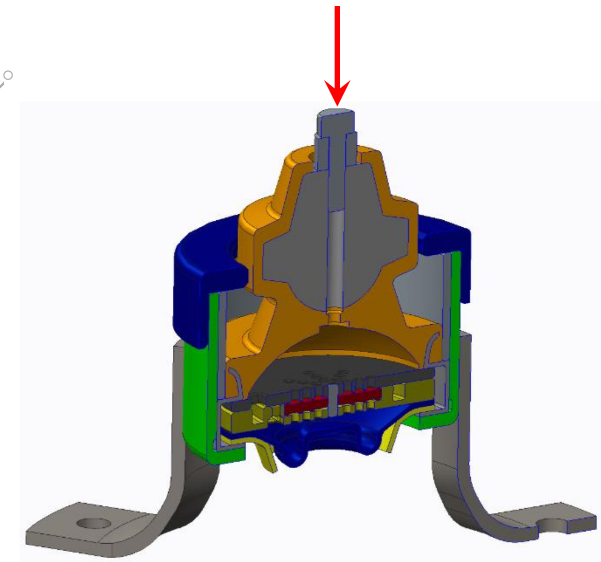
固体域流固耦合界面设置

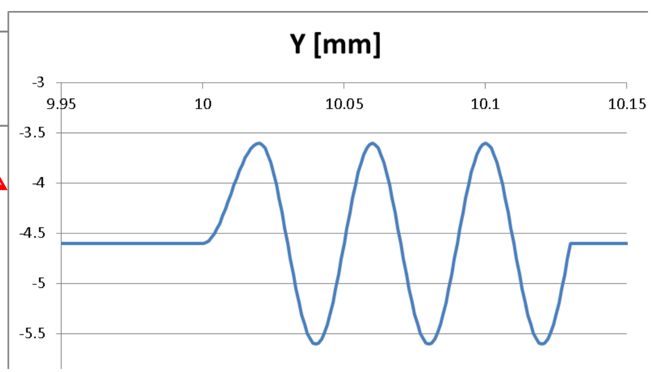


载荷设置

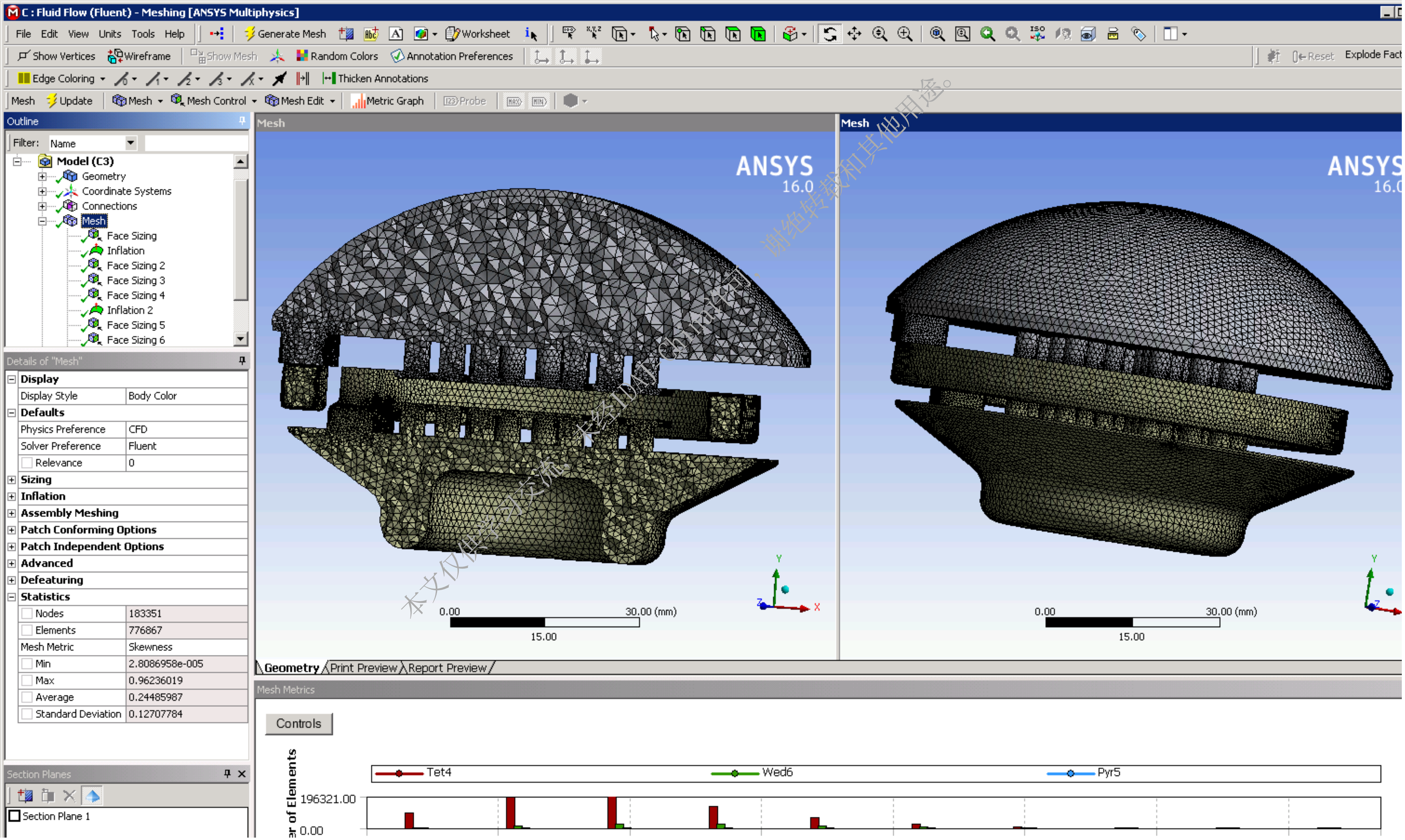
8s内4.7mm位移=>保持2s=>2mm峰峰值的振动



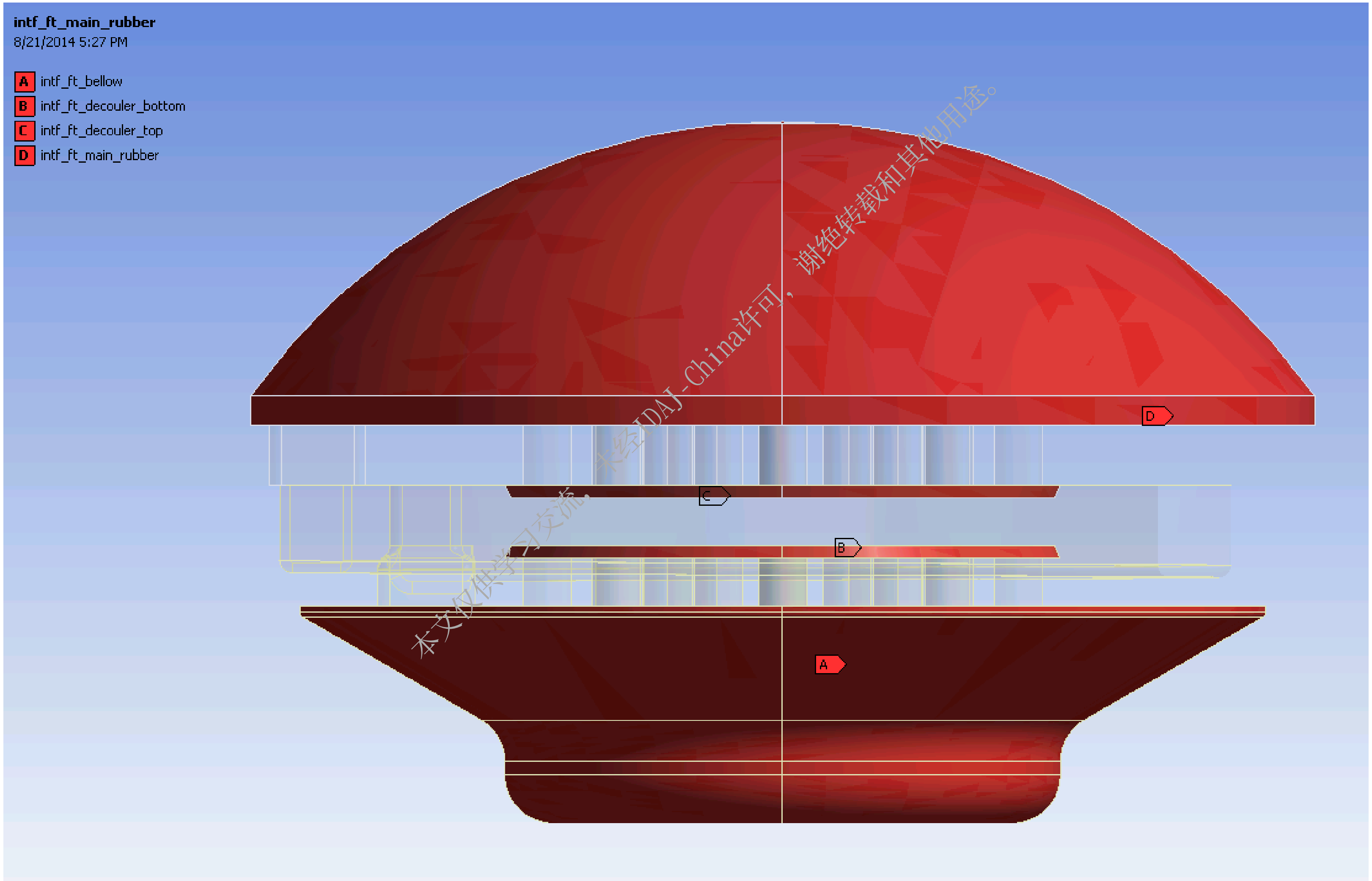




流体网格


C : Fluid Flow (Fluent) - Meshing [ANSYS Multiphysics]
Outline
Model (C3)
Geometry
Coordinate Systems
Connections
Mesh
Face Sizing
Inflation
Face Sizing 2
Face Sizing 3
Face Sizing 4
Inflation 2
Face Sizing 5
Face Sizing 6
Details of "Mesh"
Display
Display Style | Body Color
Defaults
Physics Preference | CFD
Solver Preference | Fluent
Relevance | 0
Sizing
Inflation
Assembly Meshing
Patch Conforming Options
Patch Independent Options
Advanced
Defeaturing
Statistics
Nodes | 183351
Elements | 776867
Mesh Metric | Skewness
Min | 2.8086958e-005
Max | 0.96236019
Average | 0.24485987
Standard Deviation | 0.12707784
Section Planes
Section Plane 1
Mesh
ANSYS 16.0
0.00
30.00 (mm)
15.00
Geometry
Print Preview
Report Preview
Mesh Metrics
Controls
Tet4
Wed6
Pyr5
196321.00
0.00

流体域流固耦合交界面设置



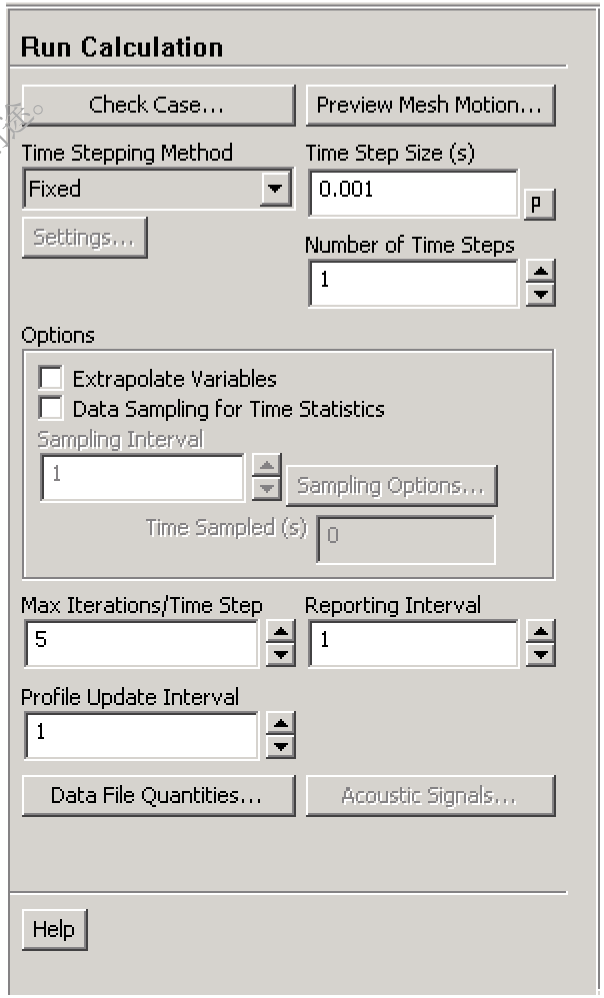
液体设置

The CFD (Fluent) simulation is setup with the following settings

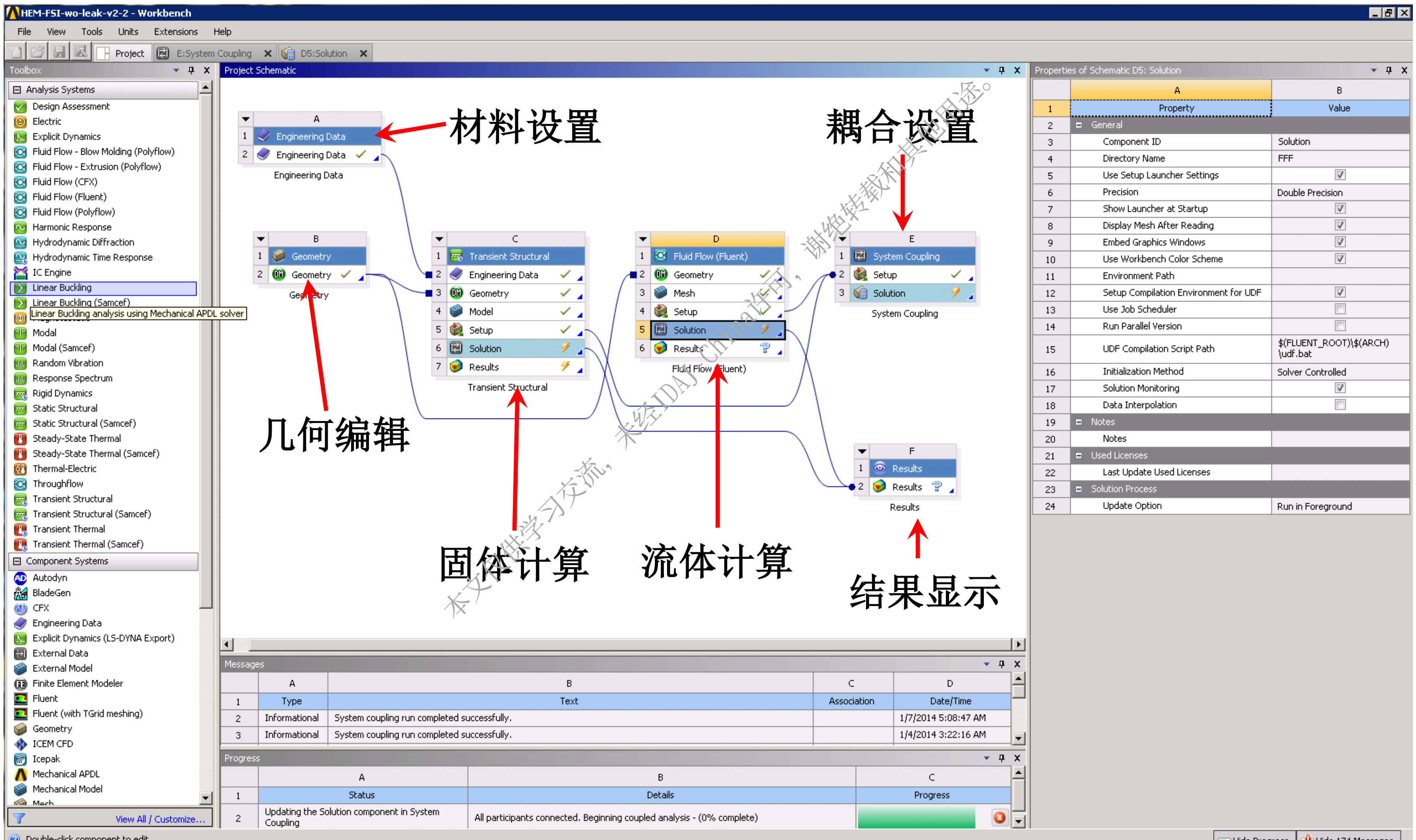
- **基于压力的双精度耦合瞬态计算**
- **SST湍流模型**
- 可压缩液体介质乙二醇

- 乙二醇属性

E = 2 Gpa
v = 1.2e-5 kg/msec
Density (reference)= 1314.425 kgm^-3
Pressure (reference) = 101325 Pa



流固耦合分析流程


材料设置
耦合设置
几何编辑
固体计算
流体计算
结果显示
Engineering Data
Geometry
Transient Structural
Fluid Flow (Fluent)
System Coupling
Results

界面间的数据传递

固体=>流体

27	⊟ Data Transfers
28	Data Transfer
29	Data Transfer 2
30	Data Transfer 3
31	Data Transfer 4
32	Data Transfer 5
33	Data Transfer 6
34	Data Transfer 7
35	Data Transfer 8
36	⊟ Execution Control
37	Co-Sim. Sequence
38	Debug Output
39	Expert Settings

Properties of DataTransfer : Data Transfer

	A	B
1	Property	Value
2	⊟ Source	
3	Participant	Transient Structural
4	Region	Fluid Solid Interface
5	Variable	Incremental Displacement
6	⊟ Target	
7	Participant	Fluid Flow (Fluent)
8	Region	intf_ft_bellow
9	Variable	displacement
10	⊟ Data Transfer Control	
11	Transfer At	Start Of Iteration
12	Under Relaxation Factor	1
13	RMS Convergence Target	0.01
14	Ramping	None

Messages

流体=>固体

27	⊟ Data Transfers
28	Data Transfer
29	Data Transfer 2
30	Data Transfer 3
31	Data Transfer 4
32	Data Transfer 5
33	Data Transfer 6
34	Data Transfer 7
35	Data Transfer 8
36	⊟ Execution Control
37	Co-Sim. Sequence
38	Debug Output
39	Expert Settings

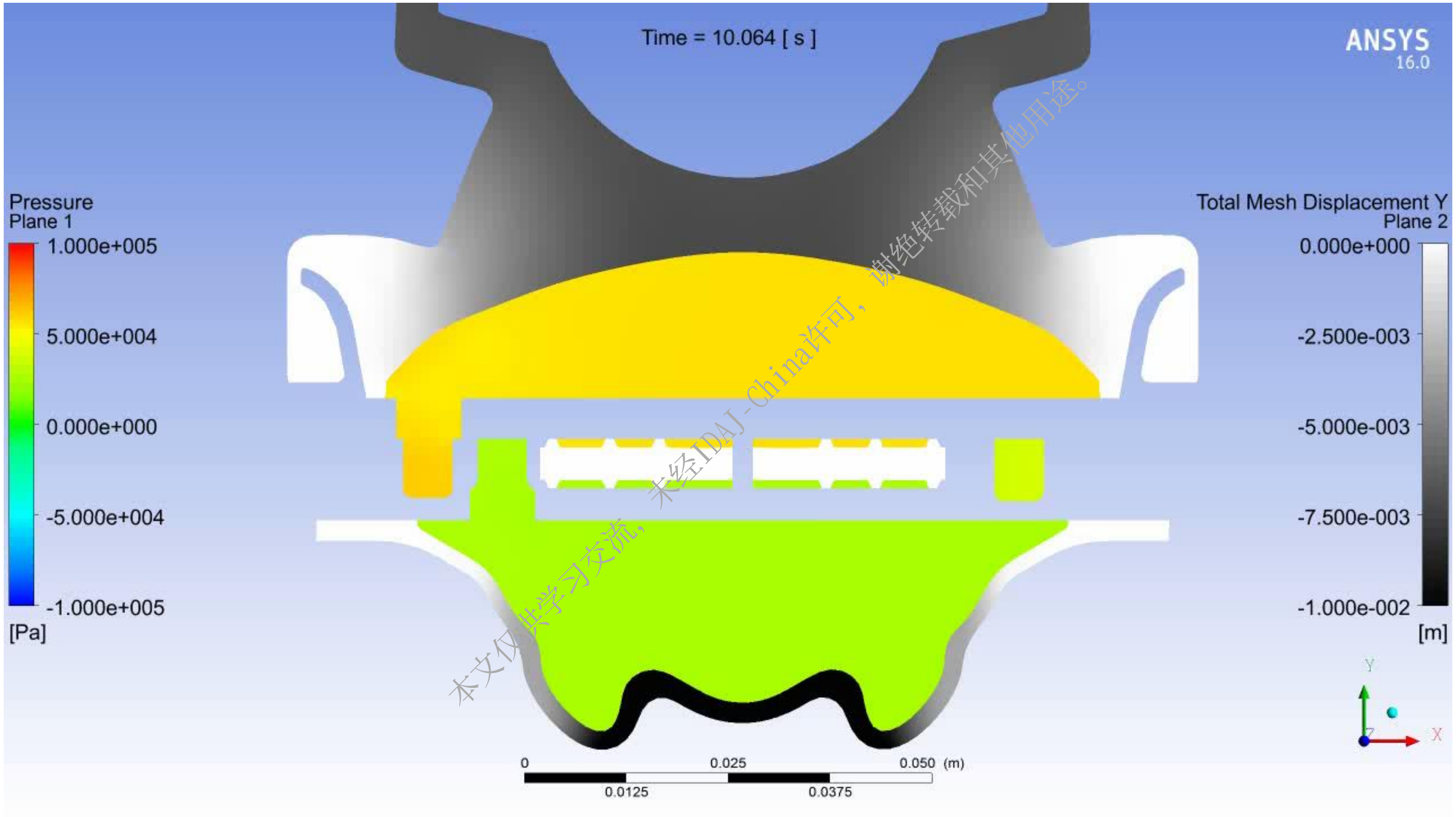
Properties of DataTransfer : Data Transfer 2

	A	B
1	Property	Value
2	⊟ Source	
3	Participant	Fluid Flow (Fluent)
4	Region	intf_ft_bellow
5	Variable	force
6	⊟ Target	
7	Participant	Transient Structural
8	Region	Fluid Solid Interface
9	Variable	Force
10	⊟ Data Transfer Control	
11	Transfer At	Start Of Iteration
12	Under Relaxation Factor	1
13	RMS Convergence Target	0.01
14	Ramping	None

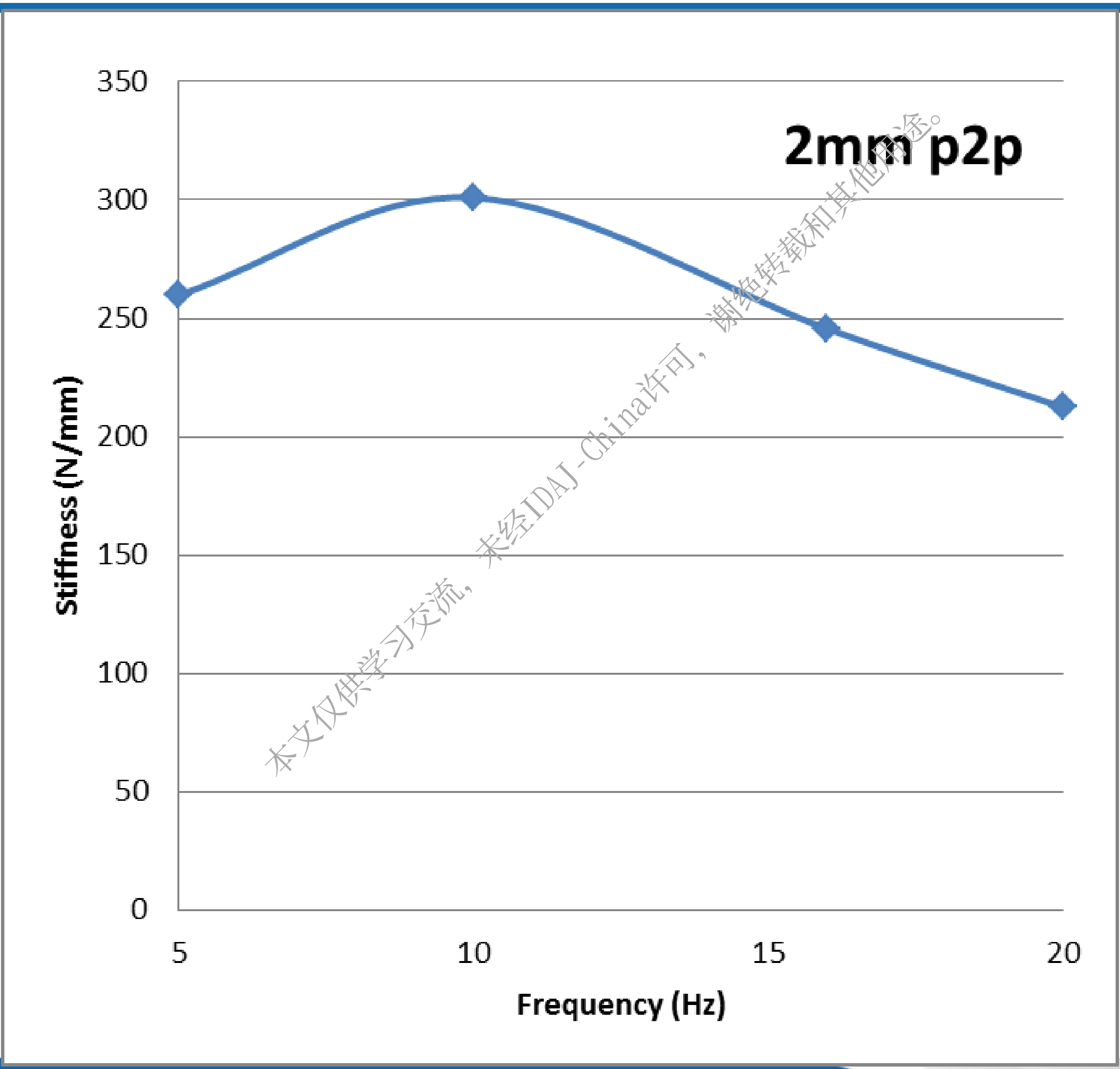
内容简介

- 流固耦合技术简介
- 发动机液压悬挂系统双向耦合仿真设置
- 发动机液压悬挂系统双向耦合仿真结果
- 总结

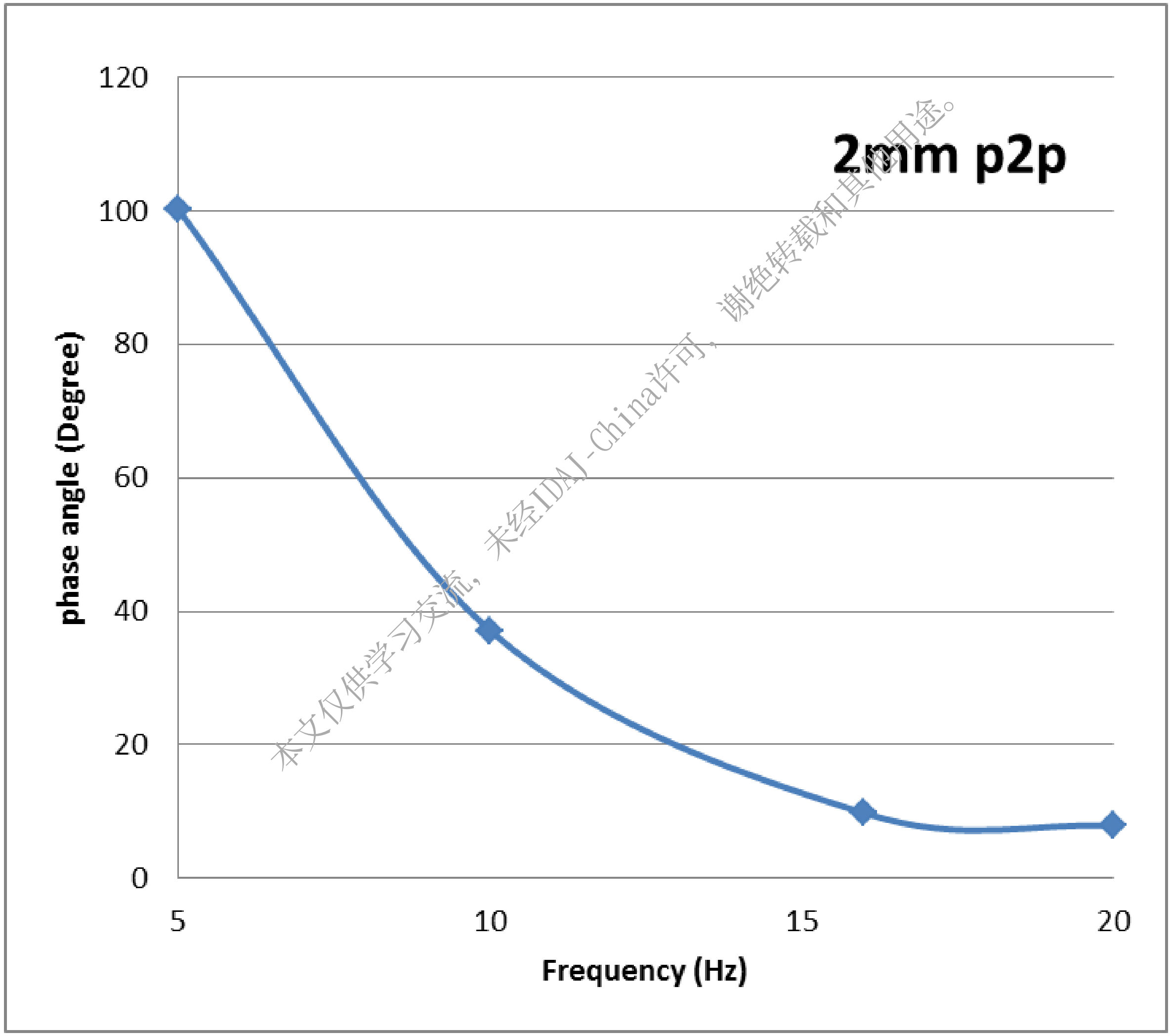
位移与压力分布


Time = 10.064 [s]
ANSYS
16.0
Pressure
Plane 1
1.000e+005
5.000e+004
0.000e+000
-5.000e+004
-1.000e+005
[Pa]
Total Mesh Displacement Y
Plane 2
0.000e+000
-2.500e-003
-5.000e-003
-7.500e-003
-1.000e-002
[m]
0
0.025
0.050 (m)
0.0125
0.0375
本文仅供学习交流，未经IDAJ-China许可，谢绝转载和其他用途。

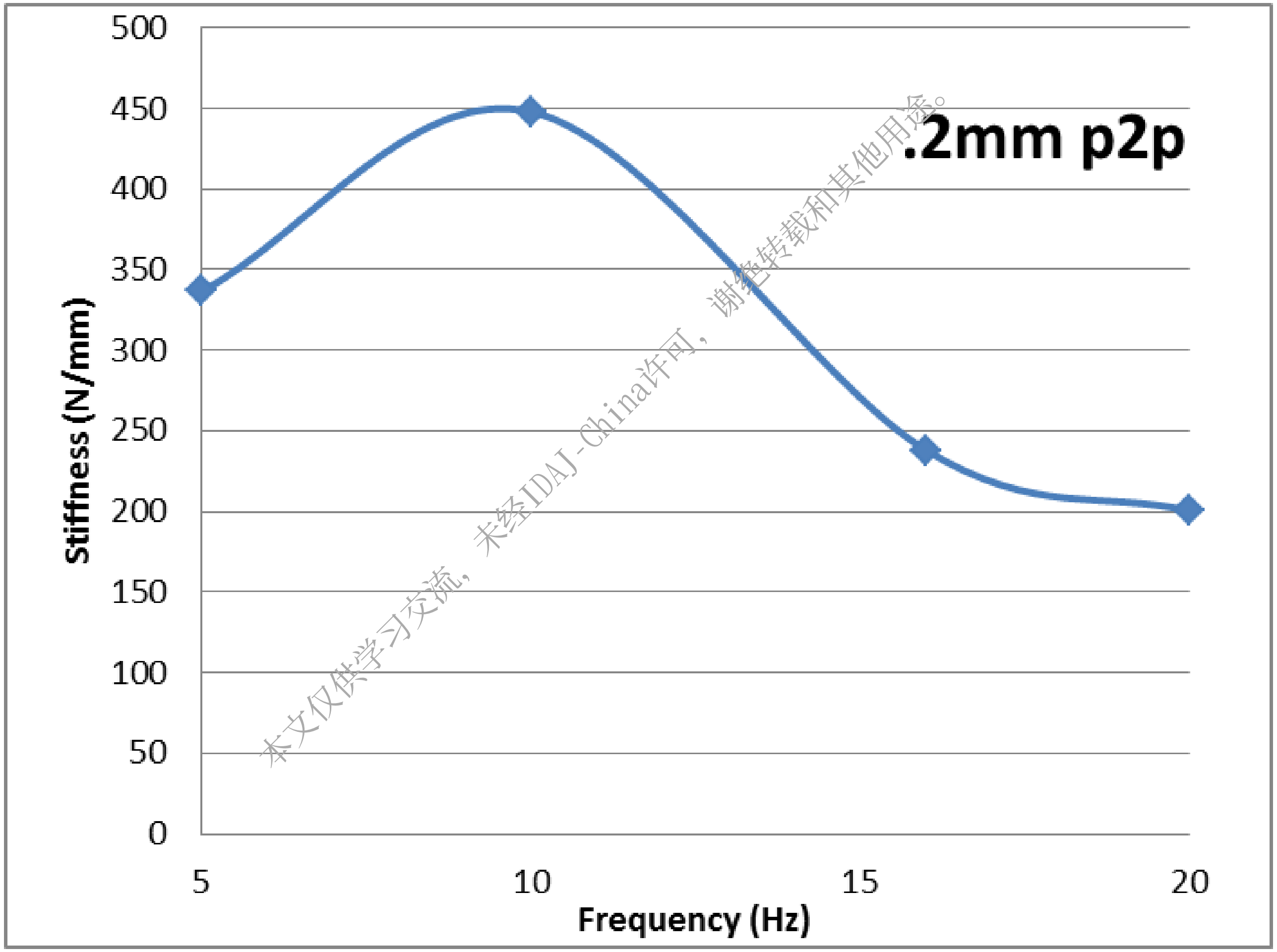
动态刚度（2mm峰峰值）


2mm p2p
Stiffness (N/mm)
350
300
250
200
150
100
50
0
5
10
15
20
Frequency (Hz)

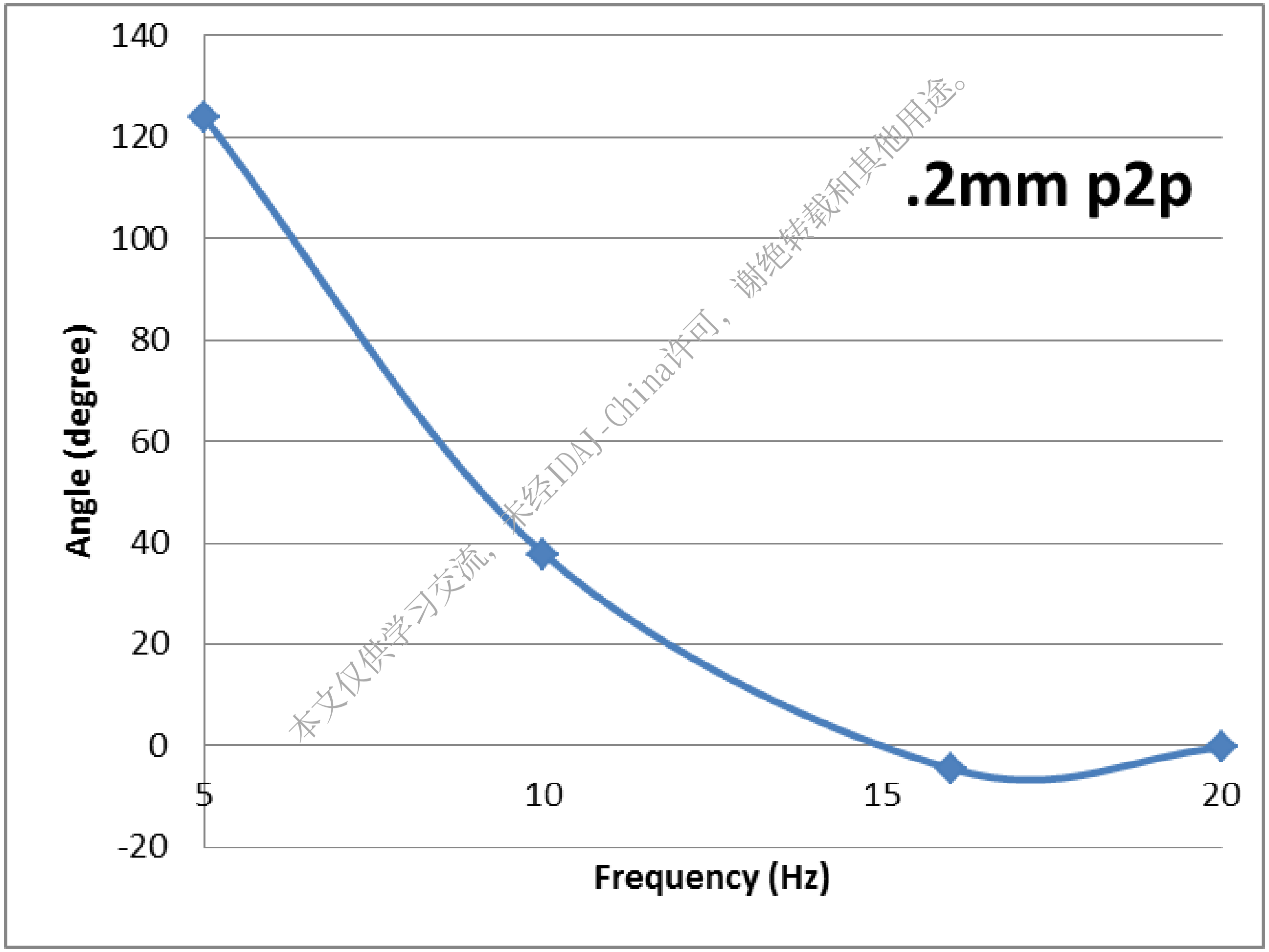
相位角（2mm峰峰值）


120
100
80
60
40
20
0
phase angle (Degree)
5
10
15
20
Frequency (Hz)
2mm p2p
本文仅供学习交流，未经IDAJ-China许可，谢绝转载和其他用途。

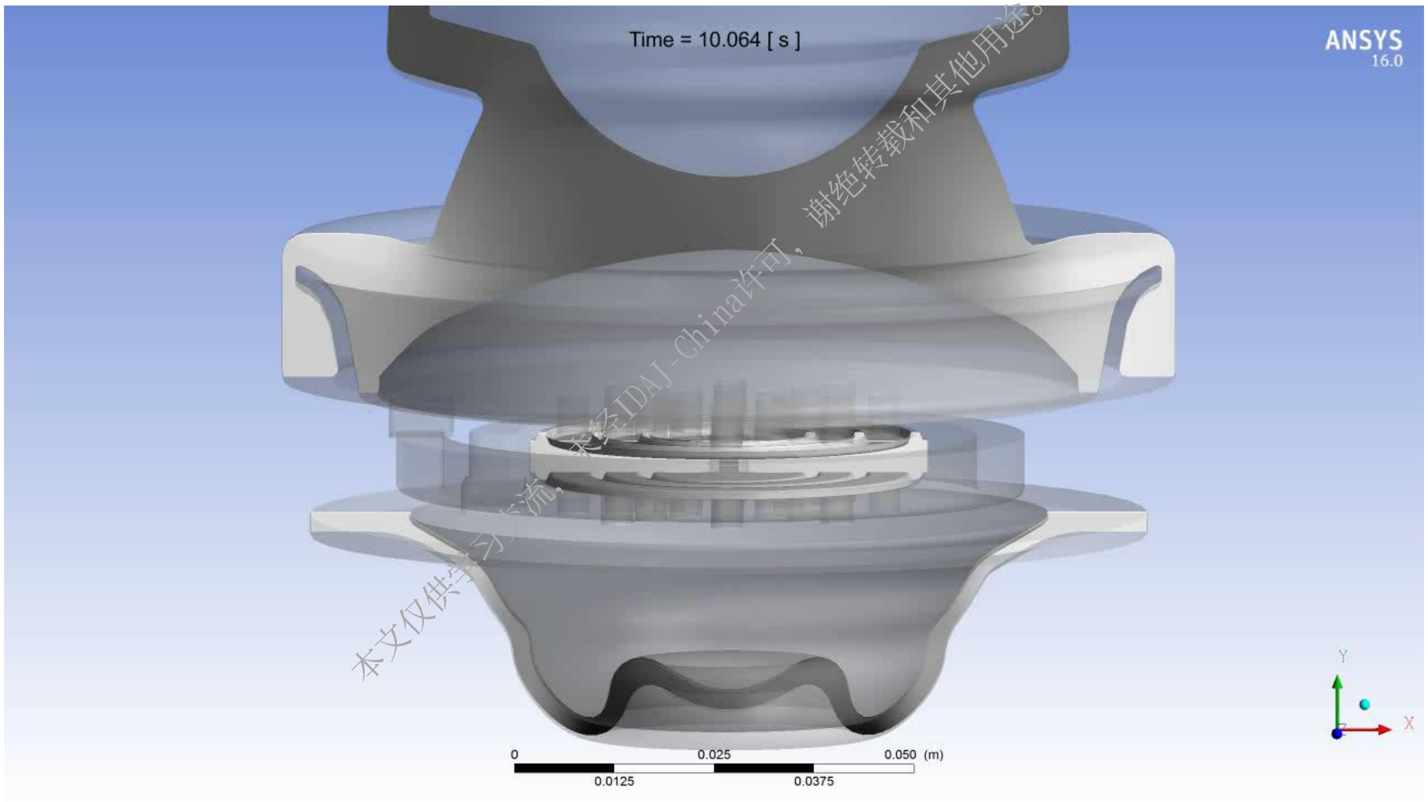
动态刚度（0.2mm峰峰值）



相位角（0.2mm峰峰值）


140
120
100
80
60
40
20
0
-20
5
10
15
20
Angle (degree)
Frequency (Hz)
.2mm p2p
本文仅供学习交流，未经IDAJ-China许可，谢绝转载和其他用途。

空化现象（4mm 峰峰值，16Hz）



内容简介

- 流固耦合技术简介
- 发动机液压悬挂系统双向耦合仿真设置
- 发动机液压悬挂系统双向耦合仿真结果
- 总结

总结

- 流固耦合技术简介
  - 分类
  - 示例
  - 工况与耦合程度
- 发动机液压悬挂系统双向耦合仿真设置
  - 耦合流程设置
  - 固体设置
  - 流体设置
- 发动机液压悬挂系统双向耦合仿真结果
  - 位移与压力分布
  - 动态刚度与相位角
  - 空化现象

欢迎扫一扫添加IDAJ-China公众账号，
及时获得CAE&CFD最新技术资讯、培训信息！

IDAJ-China
微信公众账号

IDAJ艾迪捷
微博账号

2015年4月3日消息：业界知名CAE&CFD数值仿真软件经销商艾迪捷信息科技（上海）有限公司（IDAJ中国）与美国ANSYS中国公司（ANSYS-China）正式签订ANSYS代理协议。IDAJ中国获得正式授权在中国地区分销ANSYS产品，提供技术支持及培训服务。IDAJ官网：www.idaj.cn

ANSYS产品咨询：

Email: ansys@idaj.cn

Tel: 010-65881497; 021-50588290